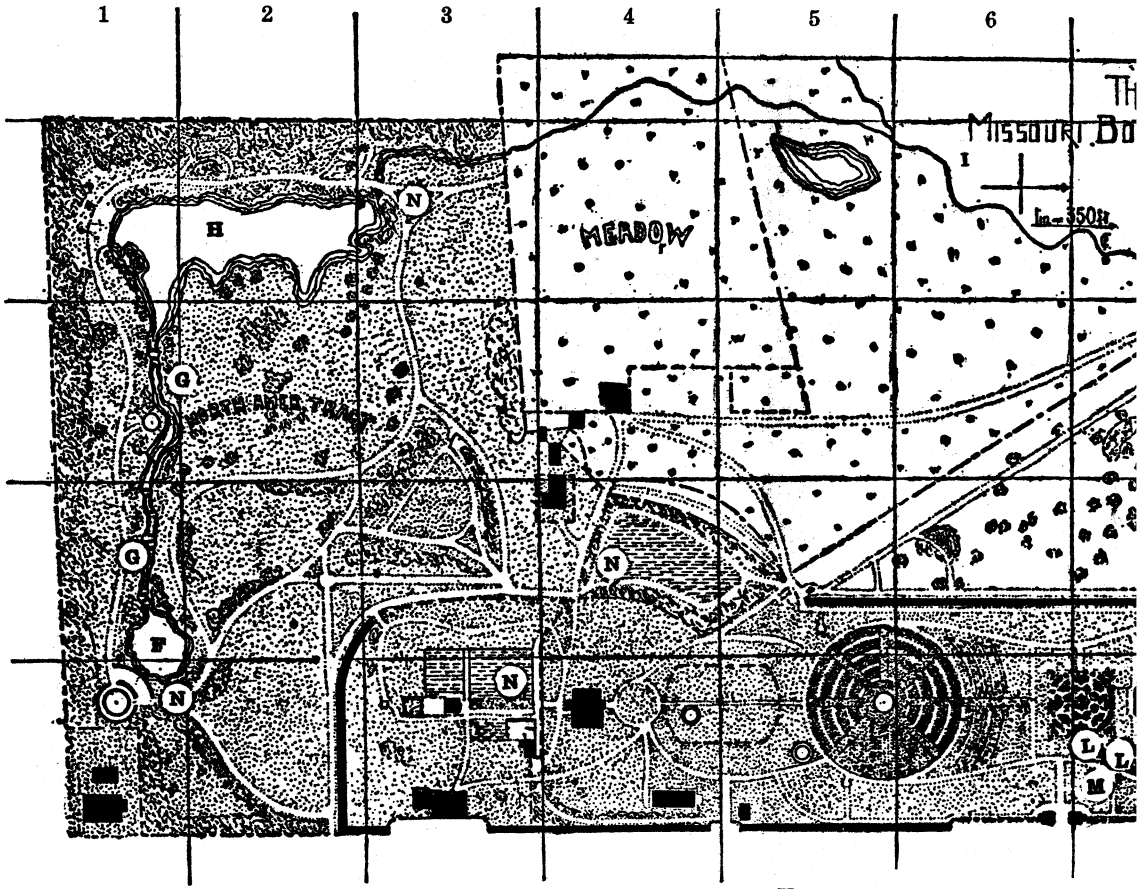
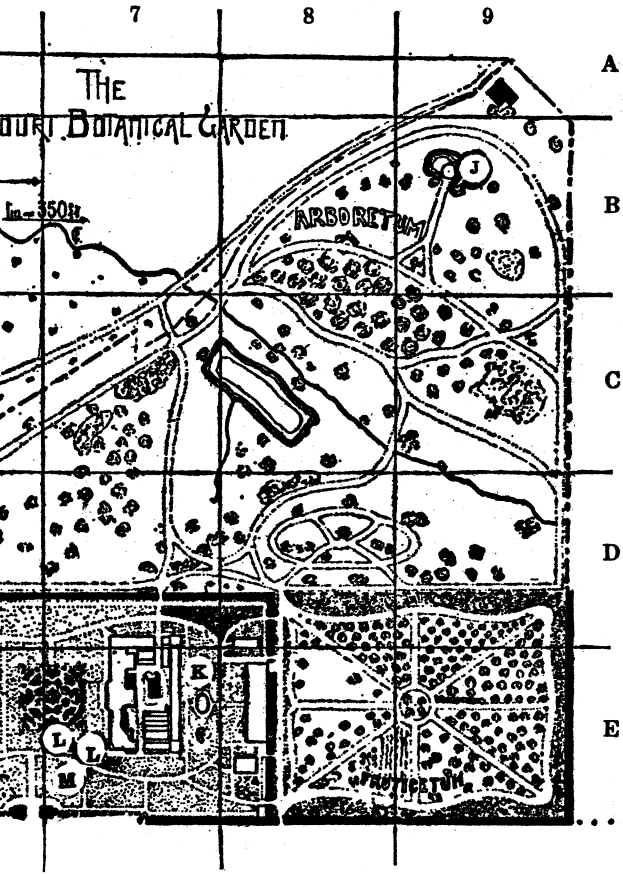


HABITATS.

F. Fountain Pond. (D 1).
Typha Pool. (D 1–2).
G. Waterfall Stream. (C–D 1).
H. Lagoon. (B 1–3).
I. Arboretum Stream. (A–D 3–9).
J. Arboretum Pond. (B 9).
K. Crescent Pool. (E 7–8).

L. Nelumbiu
M. Nymphae
N. Earth-Lo
Vegetabl
Mint Bed
Fountain
Arboretu

Waterfalls all numbered westwards, from F. to H.



Nelumbium Pools.	(E 6–7).
Nymphaea Pool.	(E 6–7).
Earth-Localities.	
Vegetable Garden.	(E 3).
Mint Bed.	(D 4).
Fountain Pond Beds.	(E 1).
Arboretum Stream.	(B 3).

'. to H.

SCIENTIFIC PAPERS.

THE ALGAL FLORA OF THE MISSOURI BOTANICAL GARDEN.[1]

BY ADA HAYDEN.

INTRODUCTION.

While holding a research fellowship in the Henry Shaw School of Botany at the Missouri Botanical Garden an opportunity was afforded to investigate the algae found in the pools, ponds and streams of that place. The work was done under the direction of Professor G. T. Moore and the determination of the species in the systematic list, based on standard taxonomic works and exiccatae, has been corroborated by Professor Moore. The photographs of the habitats were made by Mr. Emil G. Arzberger and the species marked by an asterisk are taken from a manuscript list prepared by Dr. Henri Hus some years ago.

Any habitat study of plants involves ecological principles. In the present consideration of the garden algae none of the main habitat factors *i. e.*, light, heat, temperature and water vary from what may be considered typical for this region. While the water is artificially conducted to ponds and pools its source is the Mississippi and though passed through the purification process its chemical value as regards mineral content (U. S. Bull. Bur. Pl. Ind. No. 64) is not essentially different from that to be found in any chance location. It is seldom, however, that such a variety of types are found in such a limited area. This may be accounted for by the fact

[1] Abstracted from a thesis presented to the Faculty of Washington University, in candidacy for the degree of Master of Science, June, 1910.

that the artificial arrangement of pools, ponds and streams brings within a small space a varied number of natural conditions such as small bodies of quiet, shallow, constantly renewed water with or without outlet, swiftly and slowly running streams, etc.

So far as the sources of a fresh-water algal flora are concerned, there are present the possibilities of dissemination by (1) currents of air bearing spores through short distances; (2) transportation by birds, animals and insects. It has been observed in a study of the dissemination of *Lemna,* by Mr. C. H. Thompson, that *Belostoma americanum,* commonly found flying about electric light globes on the street, carried *Lemna* attached to its body. This insect stays in the water during the day and flies about at night. If this is true of *Lemna* it might easily be true of algae which grow in the same habitats. (3) Introduced plants in ponds and pools, many of which are of tropical origin, thus having been derived from widely differing habitats. There is but slight possibility of dissemination through the agency of water currents directly except within the garden itself, for only two small streams enter it, and the boundaries due to street or grading are higher than the surrounding territory. Of the two small streams, which enter, the one from the south drains the grassy, sparsely wooded portion of Tower Grove Park and during the period under observation has been quite free from algal growth large enough to be noted without microscopic inspection. The stream which comes from an ordinary city block on the west contains few or no algae and is often dry. It is evident from the chart that the main bodies of water within the garden are connected and it is to be noted that the city water at its entrance is free from all vegetation.

Having considered these deviations from the probable typical environmental characters and those characters bearing on the source of the algal flora, it is evident that this large number of forms present, offers a good opportunity for consideration of their relative grouping and adaptation to habitat conditions which in range and variety express in miniature the probabilities of a much larger area.

HABITATS.

The habitats observed in this study are indicated by letters on the phyto-geographic map. For purposes of discussion they may be resolved into the following types:

I. Moist earth.

II. Water.

Running.

a. Waterfalls.

b. Rocky stream beds, *e. g.*, Arboretum stream.

c. Smooth stream beds, *e. g.*, Arboretum stream in part. Waterfall stream in part.

Quiet.

a. Ponds or pools with no outlet, *e. g.*, Crescent pool. Arboretum pool and Nelumbium pools.

b. Ponds or pools with outlet, *e. g.*, Fountain pond lagoon.

Having viewed the general problem of habitat characters it is in order to consider the particular conditions in the locations studied which, for convenience may be designated as Fountain pond, Waterfall stream, Lagoon, Arboretum stream, Arboretum pond, Nelumbium pools, Nymphaea pool, Crescent pool. Their location in the garden may be seen in the phyto-geographic map. The first four in the series are connected in the order named and as may be seen lie respectively in the lowest part of the tract between rolling elevations which drain into them. The surrounding territory is grassy with the exception of the Arboretum stream where the herbage is sparse due to the shade and more or less of loose soil. The fact that these bodies of water are connected makes quite probable the dissemination to succeeding connected bodies of water of anything which grows in the first of the series.

Some of the more obvious habitat characters in conformation to which plants arrange themselves in groups may be mentioned. The amount of moisture in the earth depends on precipitation, air currents and heat, of which the two latter affect evaporation from the earth; also level of water table and type of soil whose greater or less porosity affects the water holding and retaining power.

In water habitats are encountered such factors as depth, motion, rapidity of running water; attachment surfaces, *i. e.,* vertical faces of rocks subject to direct force of water; concave or protected surfaces under waterfalls where the atmosphere may be saturated and surfaces moist though plants are not submerged; soft, smooth, muddy floors of streams from which thalli may be easily swept by variation of currents depending on variation in volume of water which fluctuates periodically with rains; rocky, brick or cinder covered beds; the better aeration of water rapidly running over rocky beds; turbidity of water; presence or absence of sewage or decaying vegetation; wave beaten rock surfaces subject to variable water level; stagnant pools with no outlet; and little aeration with tendency to accumulate vegetation.

Stability of Habitat Characters.

These particular habitat characters are naturally affected by the more general meteorological conditions and granting that the physical characters of a habitat are fairly constant, the percentage of plants that might be able to live under those physical conditions at that time may become necessarily diminished in that some may become so prolific as to monopolize so large a proportion of light, moisture, space or nutriment, *i. e.,* life necessities, as to crowd weaker ones out. These stronger dominant plants, however, may serve as a protection to another type which might not have found the original conditions favorable for existence, hence the equilibrium is subject to continuous variation. It is evident that physiological, physical and biotic factors in the ecological problem are closely related. While physiological factors are of vital importance in the study of associations it will hardly be possible to give them specific consideration though an attempt will be made to note as far as possible the influence of physical and biotic factors.

Analysis of Habitats.

The Fountain pond is at an average 100 ft. in diam. and 4-5 ft. deep in the center, gradually sloping to the edge. The

water (city water derived from the Mississippi) enters at two points, the fountain in the center of the pond and a pipe at the south side. The level is fairly constant except in rainy weather, when it is variable. The water as it enters the pond maintains a fairly constant temperature, varying slowly through the year, the temperature being practically the same as that of the earth at four feet. It is covered in the winter with a coat of ice for about two months. The algae here group themselves into free swimming, those attached to water plants such as *Nymphaea* and *Potamogeton* (stationary) or attached to *Azolla* (floating). The free floating groups are swept across the surface of the pond by winds and in overflows after rains are swept down the stream.

Of the algae listed for this habitat, *Bulbochaete,* the *Spirogyras, Mougeotia, Palmodictyon, Cladophora,* and *Oedogonium* were at some stage attached. The others were floating or free swimming. *Pleodorina* was always found in warm, shallow water near the edge of the pond in a tangle of filamentous algae and small water plants as was generally true of the Volvocaceae in this pond. This piece of water contains several Spirogyras, only three of which have been determined, since conjugation had not taken place. All the filamentous forms are more or less closely associated in masses, *Spirogyra* and *Oedogonium* being predominant.

Typha angustifolia pool. This pool at the edge of the Fountain pond is about 4×6 ft. in size and seldom contains more than five inches of water, usually about two inches, and is often muddy without standing water. It contains a thick growth of *Typha angustifolia.* Observations were not taken here until March when an interesting association was found.

Mougeotia scalaris, Spirogyra tenuissima and *Gonatonema* sp. formed a closely interwoven mass in the spaces of which were several species of *Cosmarium, Closterium* and one of *Micrasterias.*

Waterfall stream. This stream connecting the Fountain pond and Lagoon contains fourteen waterfalls, all of which have limestone surfaces with the exception of X and XII, whose surfaces are cement covered.

Cladophora sp., *Pleurococcus vulgaris,* and *Stigeoclonium tenue* are the only forms found on the rocks themselves. *Pleurococcus* grew on all the rocks presenting a saturated surface, except the cement falls and *Cladophora* grew below the water-level of the stream at the base of the waterfalls X, XI, XII, and XIII. Some of this *Cladophora* was the same species as that which grew on the rocks of the Lagoon. *Stigeoclonium* was present on all the falls in the parts where the water ran rapidly or struck breaking into spray; especially where it fell perpendicularly on a horizontal surface, these being the points of greatest aeration. A few small plants sparsely scattered were found on the perpendicular surfaces of the two cement waterfalls X and XII over which the water ran slowly in an unbroken stream. Whether the undesirability indicated by the absence of vegetation here was due to the cement or to the flow of the water is difficult to say. So far as water is concerned conditions were similar to those where *Cladophora* and *Pleurococcus* grew on the other falls but none appeared here. *Stigeoclonium tenue* grew abundantly on waterfall I all winter, but by the 16th of May was quite degenerate, the fall becoming covered with small leeches. *S. tenue* was noted on all of the falls but X, whose face was shaded by cat-tails and IX, over which the water ran sluggishly with little fall. All the other forms found in the intervals of the stream between the falls have been noted in the Fountain pond with the exception of *Hydrodictyon,* which probably originated there. It grew in a tangle of filamentous forms among the stems of cat-tails.

The Lagoon is a long, irregular body of water 130×540 ft. and approximately 12 ft. max. depth. It is deepest at the west side and slopes gradually toward the east. This larger body of water yields slowly to temperature changes, freezing later than the upper pond. On cold mornings when the small pond had a fringe or thin coating of ice the lagoon had none. The greater size makes the force of the wind of more importance here as waves starting from one side on reaching the other beat the floating fronds against the earth. *Oedogonium* is abundant on the shallow east side of the lagoon. The

vegetative state which lived through the winter in the lagoon compared with that of the upper pond and stream was found to be badly beaten by the wave motion. The pond on the south and west side becomes abruptly deep. The prevailing winds during the growing season are in a southerly direction. These combined factors seem to make the shallow east and north side a more valuable field for algal forms which are practically absent from the west side except at the northwest rocky dam which separates the lagoon from the overflow stream. Here on the rocks is a group which must adapt itself to the wave motion and rise and fall of the water level which is variable within a range of 6-8 inches.

The lagoon, probably due to the fact that it is a larger body of water with more variability of habitat shows less connection between groups. On the deep south and west shores only a few strands of *Oedogonium* were noted. On the shallow east side, abundant *Oedogonium,* apparently the same species as that in the Fountain pond and some *Spirogyra* were present. On the mud at the north end, in March for a brief period, a thick film of *Chlamydomonas* was seen. The rock of the dam at the west was the most favorable situation. There a slender *Cladophora* sp. grew all the year. *Spirogyra, Phormidium, Oscillatorias,* Desmids, Diatoms and *Tetraspora* were prominent during parts of the year. The most conspicuous association and the only well-marked one was that of *Anabaena Flos-aquae, Clathrocystis aeruginosa* var. *major,* and *Oscillatoria Agardhii* floating on the water often mixed with quantities of soot when the wind blew the smoke in that direction. (See *Anabaena* description.) Conjugatae and Cyanophyceae are predominant.

Arboretum stream. The water from the lagoon after it enters the pasture to the northwest contains only some fragments of *Spirogyra* or *Oedogonium* until it enters the Arboretum. Near the center of the Arboretum the incline becomes more abrupt than above, the bed is here narrower and rough with bricks and stones. Here *Cladophora* flourishes. Toward the east side of the Arboretum the bed widens and the slope is slight so that the current is sluggish. In this

region a sewage pipe enters. Here *Oscillatoria* is dominant. The floor of this stream is smooth and muddy. The surface of the water is never frozen in winter. It varies in volume with precipitation and becomes very turbid at these times.

Cladophora canalicularis during the winter was covered with diatoms which as the spring advanced diminished until by the first of May they had disappeared. The plants looked ragged and unhealthy at this time, but soon began to branch and regain their bright green color. On the stones near *Cladophora, Stigeoclonium glomerata* suddenly appeared in the spring and within a month disappeared. In the east end of the stream where the water was sluggish the Blue Greens were the principal forms. On the mud at the edge of the water in this region, a small form of *Vaucheria* grew,—a different species from the one in the Arboretum pond. Here the dominant forms were present during the whole period of study.

Arboretum pond. This is a small crescent shaped body of water from a few inches to two feet deep. It has no outlet so that the water is stagnant. It contains much decaying as well as living vegetation, consisting of *Typha, Juncus, Iris, Acorus* and *Nymphaea,* which makes conditions favorable for a rich growth in algal forms. This pond freezes earlier and remains frozen longer than the Fountain pond.

This body of water has more characteristic forms than any other. In the west wing planted with *Iris* is about ½ in. of water. Here *Vaucheria* forms a thick mat with several Closteriums (see list) *Oscillatorias* and a *Lyngbya* scattered among its filaments. In the center and east wing in deeper water the other algae were attached to the stems of *Acorus* or *Nymphaea* or floating in a tangle of decaying vegetation. *Oedogonium* was very rare here, though common in the habitats which had *Cladophora. Tetraspora* was first attached then floating over the whole water surface. Scenedesmaceae were practically absent. Chaetophoraceae are predominant. This is the only location in which Ulothricaceae were found.

Nelumbium pools. These are two cement basins with no outlet. The water is 2–3 in. deep. They are covered in win-

ter by mulching, freeze early and remain frozen late. The *Nelumbium speciosum* which grows in them is a tropical plant native to Eur-Asia.

There are two well marked seasonal groups here. None of the fall (Oct.-Dec. incl.) were observed in the spring (Mar.-May incl.) and vice versa with the exception of the diatoms which have been found in all the stations in greater or less abundance. The four species which were particularly characteristic in the fall are *Anabaena Flos-aquae, Nostoc, Spirogyra setiformis* and *Pithophora Mooreana* (see syst. list) a new species. These genera by history are well adapted to tropical life. *Oedogonium* though represented in some degree in most of the stations was rare here. The spring group is free swimming, free floating including Volvocaceae, Flagellatae, Scenedesmaceae,—*Chlamydomonas gloeocystiformis, Euglena proxima* and *Gonium pectorale* being very abundant for a short time. This is the only location in the garden in which *Spirogyra setiformis* and *Pithophora Mooreana* were found. This with the fact that the *Nelumbium speciosum* is a tropical plant is of interest here. The genera *Scenedesmus* and *Phacus* are the best represented of the spring group with regard to species though the relative representation of each species is not great.

Nymphaea pool is a large cement basin 15×30 ft., situated between the two Nelumbium pools. The description of the Nelumbium pools applies to this one except that the water is from 6 in. to 1 ft. in depth. Here are found *Nymphaea Marliacea* var. *chromatella, N. Marliacea* var. *carnea, N. Gladstoniana* and *N. Robinsoniana.*

The algae in this pond were in the fall casually observed, not studied by weekly microscopic examinations, as those from the other locations. It was noted, however, that *Spirogyra setiformis* and *Pithophora Mooreana* were not present in the Nymphaea pool though the Nelumbium basins were but 4 ft. away. The most conspicuous thing here was a very abundant growth of *Spirogyra dubia* which was first attached to bricks in the pool becoming free as it rapidly developed. The filaments simultaneously went into conjugating state April

15, after which it sank to the floor of the pool. The free floating or swimming forms of which the other representatives consist seem scattered before this time, but when small masses of the conjugating *Spirogyra* were examined spaces between the filaments were found to be very abundantly filled with these small algae. Here Conjugatae, Volvocaceae, Scenedesmaceae and Flagellatae were represented. During the early part of May just after the *Spirogyra* had disappeared a large number of tadpoles made their appearance in the pool and the remaining small algal forms rapidly approached the vanishing point, the more abundant ones becoming rare.

Crescent pool. This is a small pool of the shape of its name with earth sides and floor and has no outlet. It contains *Acorus, Nymphaea,* several species, and *Nelumbium.* Observations were here taken during the spring, in the early part of which one form was found in this place only, i. e., *Stigeoclonium glomerata.* This pool contains more Oscillatorias than the other pools. In the latter part of April it was cleaned preliminary to the spring planting and the only forms which endured were the group of Oscillatorias.

Earth habitats. Those in which algae have been studied are: 1. Vegetable garden, *Botrydium Wallrothii* and *Protosiphon;* 2. The mint beds, *Botrydium Wallrothii;* 3. Flower beds near Fountain pond, *Protosiphon botrioides, Chlorococcum humicola, Oscillatoria animalis* and *Stichococcus subtilis;* 4. Edge of Arboretum stream, *Vaucheria* sp.

The soil of the first three locations is loess, moderately moist ordinarily, occasionally becoming quite dry on the surface. The fourth location is usually saturated, simply mud.

SYSTEMATIC ENUMERATION.

Schizophyta.

SCHIZOMYCETES.

BEGGIATOACEAE.

Beggiatoa alba (Vauch.) Trev. Stagnant water containing sewage or decaying vegetation. Arboretum stream.

SCHIZOPHYCEAE.

CHROOCOCCACEAE.

Chroococcus limneticus var. *sub-salsus* Lemm. Appeared end of May in Nelumbium pool.

Coelosphaerium Kützingianum Näg. In quiet water with larger algae. Fountain pond.

Coelosphaerium confertum W. and G. S. West. Nelumbium pools. Nymphea pond.

Clathrocystis aeruginosa var. *major* Wittr. This species was noted near the end of September, associated with *Oscillatoria Agardhii* and *Anabaena Flos-aquae* forming a conspicuous green scum on the surface of the water of the Lagoon. *Clathrocystis* was seen as late as the end of November, but *Anabaena* and *Oscillatoria* had disappeared by that time. This association has been observed by Möbius in the Botanical Garden at Frankfort with the substitution of *C. aeruginosa* for *C. aeruginosa* var. *major*.

Merismopedia tenuissima Lemm. Nymphaea pool March to May.

Merismopedia elegans A. Braun. Waterfall stream. Lagoon. Sept. to Nov.

Merismopedia convoluta Bréb. Arboretum stream. Fountain pond. Sept., Oct., Nov., June.

OSCILLATORIACEAE.

Oscillatoria Agardhii Gomont. Lagoon on surface of water associated with *Clathrocystis aeruginosa* var. *major* and *Anabaena Flos-aquae*. End of Sept. to end of Oct. (See *Clathrocystis*.)

Oscillatoria animalis Agardh. Mingled with *Stigeoclonium tenue* on the perpendicular surface of the first waterfall at the outlet of the Fountain pond. April. Noted on earth near *Protosiphon* in May. (E_3)

Oscillatoria amphibia Ag. Arboretum pond among *Oedogonium*. Some trichomes were noted 3.2μ wide, which is slightly larger than the type measurements. March, April. Rather common.

Oscillatoria tenuis Ag. Crescent pool, forming a dark green stratum on the floor of the pond,—closely associated with *O. animalis* and *O. limosa.* Mar., Apr. Abundant.

Oscillatoria chalybea Mertens. Arboretum stream. Associated with *O. limosa.* Sept., May. Common.

Oscillatoria formosa Bory. Arboretum pond. Nelumbium pool. Apr., May. Rare.

Oscillatoria limosa Ag. Lagoon. Crescent pool. Arboretum stream. Earth. This species occurs in greater abundance and in more habitats than any of the others. At the lower end of the Arboretum stream it is found in the greatest quantity. In the upper part of the stream very little is present. The upper half of the stream flows rapidly over rocks, while the lower half, into which sewage enters, flows sluggishly. Here in the sluggish part of the stream *O. limosa* covers the floor in a thick stratum, which now and then breaks up into tufts and floats away or is forcibly all carried away by freshets, after which, in a short time, the floor of the stream is recovered. Sept. to May.

Oscillatoria splendida Greville. Crescent pool. Associated with *O. limosa* and *O. tenuis.* Common.

Oscillatoria limnetica Lemm. Arboretum stream. Rare.

Lyngbya Digueti Gomont. Attached to *Stigeoclonium tenue* on 1st Waterfall and to *Vaucheria* in Arboretum pond. Rare.

Lyngbya Lagerheimii (Möb.) Gomont.*

Microcoleus vaginatus (Vauch.) Gomont.*

Phormidium uncinatum (Ag.) Gomont. On rocks West Lagoon. Very abundant, forming a thick dark green stratum. Sept. to Dec., Apr., through May.

Spirulina major Kütz. West Lagoon, associated with *Oscillatoria limosa.* Sept. to Dec. Common.

NOSTOCACEAE.

Anabaena circinalis (Kütz.) Raben. Quiet water. Lagoon. Rare. Oct.

Anabaena Flos-aquae (Lyngb.) Bréb. Nelumbium pool. Abundant in Lagoon. (See *Clathrocystis.*) Sept. to Oct.

Nostoc sp. Nelumbium pools. Sept. to Nov. Common.

Cylindrospermum minutissimum Collins. Nelumbium pools. May and June. Common.

SCYTONEMACEAE.

Scytonema Hofmanni Agardh.*

RIVULARIACEAE.

Calothrix sp. Nymphaea pool on edge of cement basin. Common. May, June. Associated with *Stigeoclonium aestivale, Chroococcus* and *Hydrodictyon.*

Flagellata.

RHIZOMASTIGACEAE.

Mastigamoeba aspera Schultze.*

HYMENOMONADACEAE.

Synura uvella Ehrenb. Arboretum pool. Sept., Oct. Rare.

OCHROMONADACEAE.

Dinobryon sertularia Ehrenb. Arboretum pond. Rare. Oct.

Uroglena volvox Ehrbg.*

CRYPTOMONADINEAE.

Chilomonas sp.*

EUGLENACEAE.

Euglena acutissima Lemm. Nymphaea pool. Rare.

Euglena acus Ehrbg.*

Euglena oxyuris Schmarda.*

Euglena proxima Dangeard. Nymphaea pool. Arboretum stream. Abundant. April, May, June. This species was noted thickly covering the surface of the Nymphaea pool, with a green scum. Many of the individuals were in motion, though the scum consisted largely of those in resting state, more or less enveloped in mucus and globular in form. At intervals this scum appears on the mud at the edge of the Arboretum stream.

Euglena spirogyra Ehrbg. Arboretum pool. Large Nelumbium pool. Fission observed Apr. 12.

Euglena viridis Ehrbg.*

Phacus longicauda Dujardin. Arboretum pool. Rare. Apr., May.

Phacus pyrum (Ehrbg.) Stein. Garden stream. Nymphaea pool. Sept., Oct., Mar., Apr., May. Rare.

Phacus pleuronectes Nitzsch. Arboretum pool. Waterfall stream. Nelumbium pool. Fountain pond. Common. Sept., Oct., Mar. to May.

Phacus triqueter Ehrbg.*

ASTASIACEAE.

Astasia sp.*

Bacillariaceae.

Navicula sp.*

Gomphonema acuminatum Ehrbg.*

Gomphonema constrictum Ehrbg.*

Heterokontae.

CONFERVALES

CONFERVACEAE.

Ophiocytium sp. Arboretum pond on *Microspora*. Rare. April.

BOTRYDIACEAE.

Botrydium Wallrothii Kütz. (E3) Cabbage patch. Earth. Associated with *Protosiphon botryoides* (Kütz.) Klebs. Nov.

Botrydium granulatum (L.) Greville. Mint beds on damp loess soil (D4). Abundant. In the first part of March on the damp soil of a flower bed (soil had not been stirred since the previous summer) was noted what proved to be *Botrydium* aplanospores in such abundance that the earth looked light green. No *Botrydium* plants were observed at this time. At the end of March in another bed in a different location were found *Botrydium* plants in abundance forming dark green masses among the more conspicuous brighter green

aplanospores. In location I. at this time the earth had dried out, the aplanospores had disappeared and no plants were observed in this place.

At the end of March most of the plants were producing aplanospores which immediately began to grow into plants. The aplanospores found earlier in the season on the earth were studied directly from the earth and in drop cultures, but showed no indication of developing into plants at that time. Usually, as soon as these aplanospores taken from the earth were placed in water, they began to produce zoospores. Others of these same aplanospores, when mature, apparently divided into another generation of aplanospores within their walls, which broke, setting the young ones free. They usually remained agglutinized in a spherical group for a time, then broke apart and grew to normal size. All of the young aplanospore cells contained clearly defined, sub-angular chromatophores, which lost their outline, becoming diffuse granular as the cells increased in size.

The aplanospores, then, may develop into plants, remain resting for a time, produce zoospores or divide into other aplanospores, depending on environmental conditions, water probably being the most important. The normal size of the aplanospores up to the time of maturity as indicated by sending out a rhizoid process or internal re-organization, is 16—38.4μ.

Chlorophyceae.

DESMIDIACEAE.

Closterium acerosum Ehrenb. Arboretum pond. Nymphaea pool. Nelumbium pools. Crescent pool. Mar., May. Common.

Closterium acerosum var. *elongatum* Bréb. Arboretum pond. Nymphaea pool. Nelumbium pools. Crescent pool. Mar., May. Common.

Closterium Lunula var. *intermedium* Gutw. Lagoon. Fountain pond. Arboretum pond. Sept., through Nov. Mar. to June. Rather common.

Closterium moniliferum Ehrenb. Typha angustifolia pool. Lagoon. Oct., May. Rare.

Closterium strigosum Bréb. Arboretum pond. Mar., May. Rather common.

Cosmarium Botrytis Menegh *

Cosmarium Broomei Thwaite.*

Cosmarium granatum Bréb. Nymphaea pool. Apr., May.

Cosmarium margaritiferum Menegh.*

Cosmarium Phaseolus var. *minor* Boldt. Nymphaea pool. Mar., May.

Micrasterias americana (Ehrenb.) Ralfs. Typha angustifolia pool, with filamentous algae. Rare. May.

Pleurotaenium Trabecula (Ehrenb.) Näg. West side of Lagoon. Rocks. Rather common.

Pleurotaenium Trabecula var. *granulata* West. West Lagoon. Rather common.

Penium margaritaceum (Ehrenb.) Bréb. Nymphaea pool. Rare. May.

Staurastrum sp.

ZYGNEMACEAE.

Spirogyra dubia Kütz. Nymphaea pool. Abundant. Conjugating Mar. 15.

Spirogyra Grevilleana (Hass.) Kütz. Fountain pond. Waterfall stream. Rather common. Sept. and through May. Conjugating early in Mar.

Spirogyra longata (Vauch.) Kütz. Waterfall stream. Fountain pond. September and through May. The material in the garden does not exactly conform to the type description. There is, however, observed a variation in the measurements given for the vegetative cells as described by Collins, who gives 20-36μ as diameter; Petit 25-30μ; De Toni, 24-30μ. There is also more or less variation in regard to the length of the cells in descriptions. Collins describes the spore as broadly ovoid; Wolle, twice as long as broad, though all state that the spore completely fills the diameter of the cell without swelling, which is true in this case, whatever may be the width of the filament. The measurements of the garden specimens are: veg. fil. 21.4-28.8μ; chromatophore up to 6.4μ with as many as 5 coils. The vegetative cells are up to 10 diameters long, usually less;

spores 21.4-28.8×48-80μ, up to 3 diameters in length, ellipsoid with rounded tips, conjugating the middle of May.

Spirogyra porticalis (Müller) Cleve. Fountain pond. Waterfall stream. Sept., through May. In an instance where 3 filaments lay parallel, the two outer filaments contained zygospores, the result of conjugation of aplanogametes from the central strand. In two cells of the central strand were two zygospores, the cells of which showed connection with cells of adjacent strands mentioned, indicative that the whole strands were not of one sex, but that the distinction of sex applies to the individual cell. Conjugation observed at end of March.

Spirogyra setiformis (Roth) Kütz. Nelumbium pools. Fairly abundant. Conjugating in November. This is the only species which conjugated in the fall (Dec.)

Spirogyra tenuissima (Hass.) Kütz. Arboretum pond. Associated with *Mougeotia scalaris* and *Gonatonema* sp. Sept. to June. Conjugating through May. Conjugation is both lateral and scalariform. The receptive cell swells before dissociation of the chromatophore. Chromatophore of male cell is usually dissociated and ready to pass out of its cell before the chromotaphore of the receptive cell has lost its spiral form. In some cases two normal appearing zygospores (aplanospores?) were found in one cell. These were somewhat smaller than the ordinary spores.

MESOCARPACEAE.

Gonatonema sp. Typha angustifolia pool. Abundant.

Mougeotia scalaris Hassall. Arboretum pond, closely associated with *Spirogyra, Microspora, Stichococcus.* Quiet waters. Conjugation observed Apr. 5. In one instance 2 gametes from one filament were conjugating with one from another adjacent filament to form a zygospore.

VOLVOCALES.

CHLAMYDOMONADACEAE.

Chlamydomonas gloeocystiformis Dill. First noted forming a thick, bright green coat on the mud of the north branch

of the Lagoon, later forming a green scum on the surface of the Nymphaea pool.

The cell remains motile long, finally becoming motionless, assuming a spherical form and lying imbedded in a gelatinous secretion. The first division in the formation of young zoospores is longitudinal, the next transverse. Dimensions, 9.6-17μ×6.4-11.2μ, while active; 6.4-12.8μ resting.

VOLVOCACEAE.

Eudorina elegans Ehrenb. Fountain pond. Nymphaea pool. Waterfall stream. Quiet water. Sept. to Dec. Colonies were breaking up the early part of Dec.

Gonium pectorale Müller. Nelumbium pools. Nymphaea pool. Arboretum pond. Producing auto-colonies Apr. 10.

Pandorina Morum (Müll.) Bory. Fountain pond. Nelumbium pools. Arboretum stream. Waterfall stream. Nymphaea pool. Sept., Dec., Mar., through June. Producing auto-colonies abundantly in April and March.

Pleodorina californica Shaw. Edge of Fountain pond. Shallow water. Colonies were observed in perfect state the last of September. During the first part of November they lost their vegetative cells and the number of colonies decreased. The colonies at this stage resembled *Eudorina*. Sept., Nov.

TETRASPORACEAE.

Tetraspora gelatinosa (Vauch.) Desvaux. Arboretum pond. Rocks, west Lagoon.

Ineffigiata neglecta W. and G. S. West. Fountain pond. Rare.

PROTOCOCCALES.

PROTOCOCCACEAE.

Chlorococcum infusionum (Schrank) Menegh. Lagoon.

PROTOSIPHONACEAE.

Protosiphon botryoides (Kütz.) Klebs. Cabbage patch (E3). Associated with *Botrydium Wallrothii* in Nov. in abundance. In March, scarce on a flower bed near Fountain pond. May, abundant. In loess soil.

SCENEDESMACEAE.

Actinastrum Hantzschii Lagerh. Nymphaea pool. Mar., June. Multiplication takes place by longitudinal division of cells. Observed Apr. 6. The size of the individual found here differs from that given by De Toni, Hansgirg, West and Chodat, *i. e.*, 3.6$\mu\times$10-24μ. The dimensions of those found in the Garden are 2.4-3.2$\mu\times$9-16μ. Colony 19.2-32μ diam.

Ankistrodesmus falcatus (Corda) Ralfs. Fountain pond. Waterfall stream. Nelumbium pools. Nymphaea pool. Abundant. Sept. to Dec., Mar. through June.

Ankistrodesmus falcatus var. *spiralis* (Turn.) West. Nymphaea pool. April-June. *Raphidium polymorphum* var. *contortum* (Thur.) Wolle, and *Ankistrodesmus contortus* Thur., according to the descriptions given in Wolle (Freshwater Algae of U. S. 198. pl. CLX., seem to be synonymous with West's *Ankistrodesmus falcatus* var. *spiralis*. Thuret's description antedates the others here mentioned.

Ankistrodesmus falcatus var. *mirabilis* West. Nelumbium pools. Waterfall stream. Nymphaea pool. Sept. to Dec., Apr., June.

Ankistrodesmus falcatus var. *tumidus* West. Nelumbium pools. Fountain pond. Waterfall stream. Nymphaea pool. Oct., May. Rare.

Coelastrum cubicum Näg. Fountain pond. Common. Sept. and Oct. Rare. The form found in the garden corresponds closely with Lemaire's figure and descriptions of *C. cornutum,* which Senn discusses and declares is not sufficiently distinguished from *C. cubicum* to exist as a species.

Coelastrum microsporum Näg. Fountain pond. Quiet water of Waterfall stream. Common. Sept. to Dec.

Dictyosphaerium Ehrenbergianum Näg. Nymphaea pool. Most abundant near the floor of the pond. Apr., May. Colonies observed here consist of 4-16 cells. Diam. of col. 16-41.6 μ;cells rather uniform in size, measuring about 3.2-6.4μ. The cup-shaped chromatophore has a red eye spot. This form corresponds closely in size to the *Dictyosphaerium*

which Bernard describes (1909 Algues Unicellulaires) from Singapore. Though smaller than the type as generally described, he considers this variable character not sufficient to establish a new species.

Kirchneriella lunaris (Kirchner) Möbius. Fountain pond. Sept. to Dec. Nymphaea pool. Mar., June. Rather common.

Kirchneriella obesa (West.) Schmidle. Nymphaea pool. Mar. to June. Producing auto-colonies in April.

Scenedesmus bijuga (Turp.) Wittr. Nelumbium ponds. Nymphaea pool. Fountain pond. Waterfall stream. Sept. to Dec., Mar., June. Common.

Scenedesmus obliquus (Turp.) Kütz. Nelumbium pools. Fountain pond. Waterfall stream. Nymphaea pool. Rather common. Sept. to Dec., Mar. to June.

Scenedesmus obliquus var. *dimorphus* (Turp.) Hansg. Fountain pond. Nymphaea pool. Nelumbium pool. Waterfall stream. Sept., Dec., Mar., June. Rather common.

Scenedesmus quadricauda (Turp.) Bréb. Fountain pond. Nelumbium pool. Waterfall stream. Nymphaea pool. Sept., Dec., Mar. to June. Common. Auto-colonies in Oct. and Apr.

Selenastrum gracile Reinsch. Nymphaea pool. Rare. Sept., Oct., May.

Tetraedron trigonum (Näg.) Hansg. Nymphaea pool. April, May. Rather rare.

Tetraedron trigonum var. **pentagonum** (Rab.) New combination. Nymphaea pool. Apr., May. Rather rare.

Wolle has described *Polyedrium trigonum* Näg.: cells somewhat compressed, 3-5 angled; angles obtuse-mucronate, sides more or less concave. Kirchner has suggested the following names for varieties (a) *typicum* Kirch.; (b) *minus* Reinsch; (c) *tetragonum* Rab.; (d) *pentagonum* Rab.; (e) *punctatum* Kirch.; (f) *bifurcatum* Wille. (See Wolle, Freshw. Alg. of U. S. 184. 1887; Kirchner, Kryptfl. von Schlesien, **2**: 104. 1898.)

Hansgirg, in his revision of this genus and reversion to Kützing's generic name has not made provision for the five-

angled mucronate-tipped form. De Toni in his summation of the varieties lists *T. trigonum* (Näg.) Hansg. and *T. caudatum* (Corda) Hansg. He does not include *Polyedrium trigonum* var. *pentagonum* Rab. or any equivalent.

Tetraedron caudatum (Corda) Hansg. Nymphaea pool. Rather rare. Apr., May.

HYDRODICTYACEAE.

Hydrodictyon reticulatum (L.) Lagerheim. Waterfall stream. Nelumbium pool. Apr., May, June. Rather common.

Pediastrum Boryanum (Turp.) Meneg. Fountain pond. Nymphaea pool. Common. Sept., Dec., March to June.

Pediastrum duplex Meyen. Fountain pond. Nelumbium pools. Nymphaea pool. Sept. to Dec., Mar. to June. Rare.

Pediastrum tetras (Ehrenbg.) Ralfs. Nelumbium pools. Nymphaea pool. Fountain pond. Sept., Mar., Apr., May. Rather common.

ULOTHRICACEAE.

Microspora stagnorum (Kütz.) Lagerheim. Arboretum pond. Associated with *Spirogyra* and *Stichococcus*. Akinetes produced in the early part of April. Abundant. Mar., Apr., May.

Stichococcus subtilis (Kütz.) Klercker. Earth near Fountain pond. (El) Apr., May. Rather common.

OEDOGONIACEAE.

Oedogonium sp. Fountain pond. Lagoon Waterfall stream. Arboretum stream. Abundant. Sept. to June. Zoospores abundantly produced in Sept., Oct., Nov. They were enclosed in a delicate enveloping sac in which they came out of the cell and from which they escaped in a few minutes. Sexual reproduction beginning in June.

Bulbochaete sp. Fountain pond. Sept., Oct., Nov. Rare.

ULOTHRICALES.

CHAETOPHORACEAE.

Chaetophora elegans (Roth) Agardh. Attached to stems of *Juncus*, mixed with filamentous algae. Arboretum pond. April May Rare.

Draparnaldia plumosa (Vauch.) Agardh. Arboretum pool. Jan., Apr. Rather common. Produced zoospores in March.

Stigeoclonium aestivale (Hazen) Collins. Arboretum pond. Growing on stems of *Nymphaea* and *Acorus*. Nymphaea pool on edge of cement basin.

Stigeoclonium lubricum (Dillw.) Kütz. Rocks in upper part of Garden stream, running water. This species was observed in the Garden stream in March only. It appeared abruptly, grew to maturity rapidly and disappeared as suddenly as it came. Though collections were made weekly, it was difficult to determine the exact time of its disappearance. It was noted by the 1st of April.

Stigeoclonium stagnatile (Hazen) Collins. Fountain pond. Floating, associated with *Spirogyra* and *Mougeotia*. Oct.

Stigeoclonium glomeratum (Hazen) Collins. Crescent pool. Abundant during March and early part of April. Pond was cleaned and it did not reappear. Cells of main branches were on an average 3–4 times the diameter of the cell. Long cells were rather exceptional, though they were noted up to 8 diameters in length. Great variation in branching was noted, some branches having few fascicles, while others showed a marked fasciculate tendency. The thalli in mass were very gelatinous.

Stigeoclonium tenue (Ag.) Kütz. Waterfall stream on face of waterfalls. The form growing in the garden is setiferous. It was found growing abundantly on the perpendicular surface of the first waterfall in Sept., where it grew with little variation in quantity through the winter and spring. Water ran over the fall all winter, though under a frozen surface coating of ice. It was observed in small patches in the autumn on several of the other falls, which presented a perpendicular or slanting surface, washed by the water. During the winter water flowed not over, but under the other falls, the surface of which dried out. The second waterfall presented a striking bright green patch on the horizontal surface of a shelving rock which the water struck as it fell

perpendicularly from a shelf above. Young *S. tenue* began to grow in the latter part of March. Zoospores were produced abundantly in the fall.

Microthamnion Kützingianum Näg. Crescent pool with *Stigeoclonium glomeratum*. Rare. April.

Palmodictyon viride Kütz. Fountain pond among filamentous algae and partially decaying aquatic plants. The cells of the thalli here were 6.4-9.6μ in diam., rarely 12.8μ. Rare. Oct., Nov., May, June.

Pleurococcus vulgaris Menegh., not Näg. On the saturated surface of rocks over which water seeps. Waterfall stream. Common. Sept., June.

SIPHONOCLADIALES.

CLADOPHORACEAE.

Cladophora canalicularis (Roth) Kütz. Attached to rocks in the bed of the rapidly running Arboretum stream. This *Cladophora* covered the rocks with a thick coat of cool green color during the fall, first observed in Oct., which became grayish, yellowish and dingy during the winter, when it became covered with a thick coat of diatoms. The diatoms began to diminish in number near the first of April, leaving the *Cladophora* looking ragged, limp and unhealthy. Some fresh new branches were then sent out from the old weather-beaten thalli, and young plants also began to grow. Some of the cells were filled with dense protoplasm resembling the prolific cells of *Pithophora*.

Pithophora Mooreana Collins MS.[2]

This *Pithophora* was first observed in the garden by Dr. Moore in Nelumbium pool. The description by Mr. Collins is not yet published. The plants were growing in Sept. and Oct. in the small Nelumbium pools. In Oct. spores were very rarely seen. After the first frost spores were formed

[2] Closely related to *P. Summatrana* but differing in dimensions and in the grouping of spores, which are borne in groups of one, two or three in *P. Mooreana*, the spores of *P. Summatrana* being borne singly.

sparingly. Some *Pithophora* kept in a glass jar in water from the pool was observed in Jan. to have abundant spores. The plants at this time broke up easily. The akinetes were arranged 1, 2, and not uncommonly 3 in a group. Spores are usually borne at the upper end of the cell, terminal or intercalary. In a few instances swellings globular in form just below the akinete at the top of the cell, were noted. This swelling was preliminary usually to the formation of a spore, but in some cases there appeared to be not enough of protoplasm to form a second spore in the cell, while in other cases twin spores were developed in a cell. Twin spores were usually observed in the branches, not in the main stem. Akinetes of the main stem are cylindrical (square to rectangular in outline) little, if any, swelled. Akinetes of the branches were cask shaped. In twin groups the cells were either similar in shape or one cylindrical and one cask shaped. The branching is one ranked. In only two cases were rhizoid-like structures observed. The measurements are:

Akinetes.	Max.	Av.	Min.
L.	380μ	114μ	95μ
W.	114	95	57
Side Branches	665—	114μ	
Main Stem	114—	142.5μ	

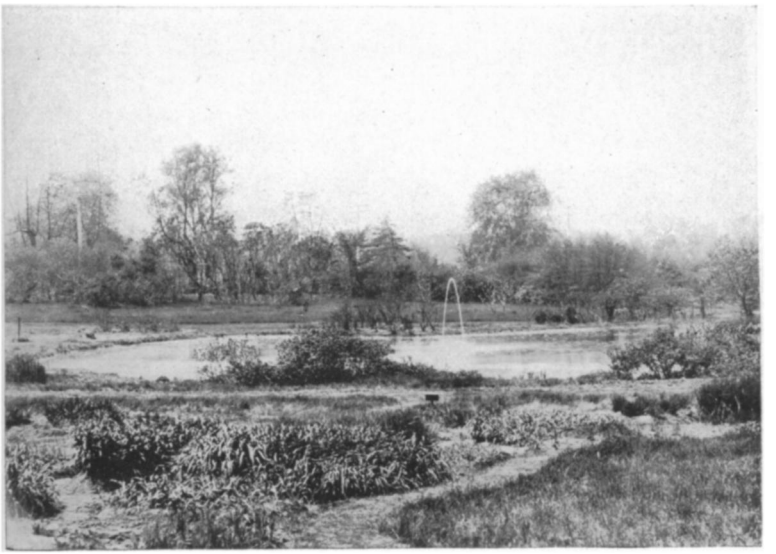
Pithophora Oedogonia (Mont.) Wittr. Fountain pond. Oct., June. Akinetes produced in June. Rather rare.

Rhizoclonium hieroglyphicum (Ag.) Kütz.*

SIPHONALES.

VAUCHERIACEAE.

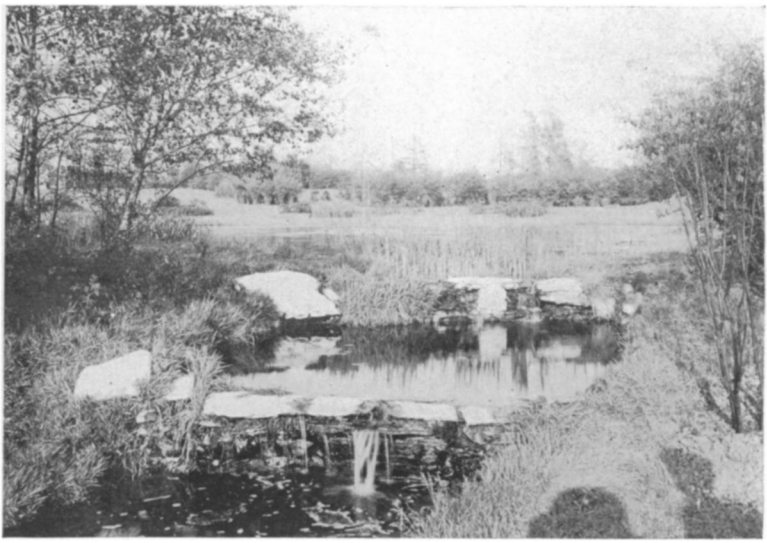
Vaucheria sp. Mar. to June. Submerged or terrestrial. West Arboretum pond and mud of Arboretum stream.



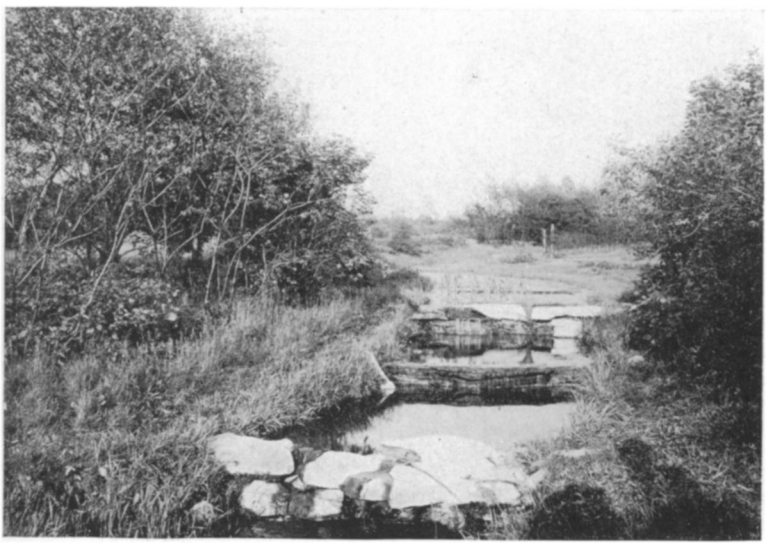
FOUNTAIN POND.

LAGOON.

ALGAL HABITATS.



FIRST AND SECOND WATERFALLS.



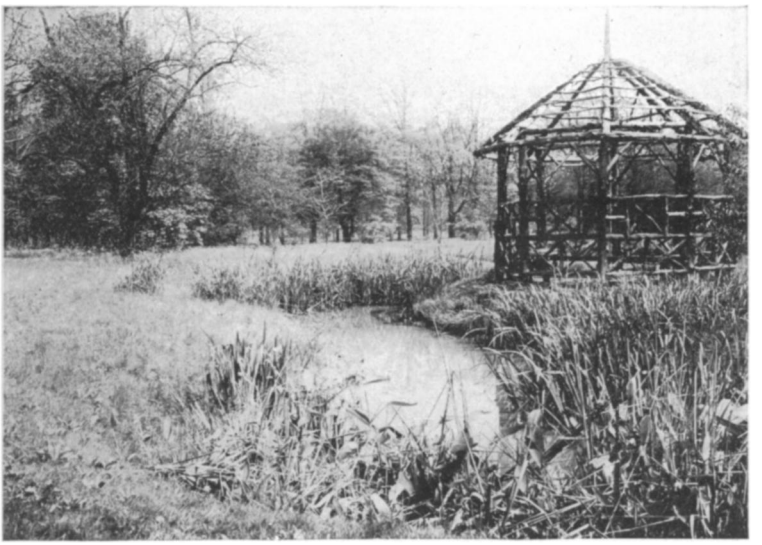
TWELFTH, THIRTEENTH AND FOURTEENTH WATERFALLS.

ALGAL HABITATS.

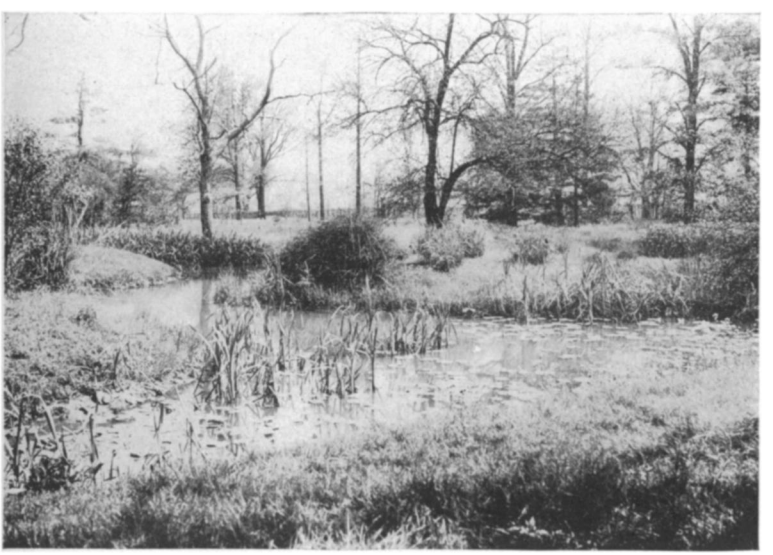
WEST ARBORETUM STREAM.

CENTRAL ARBORETUM STREAM

ALGAL HABITATS.

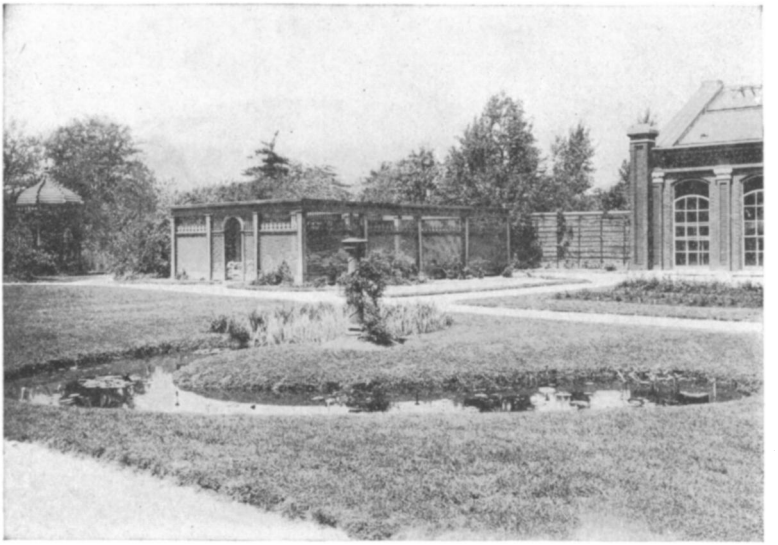


ARBORETUM POND—EAST SIDE.

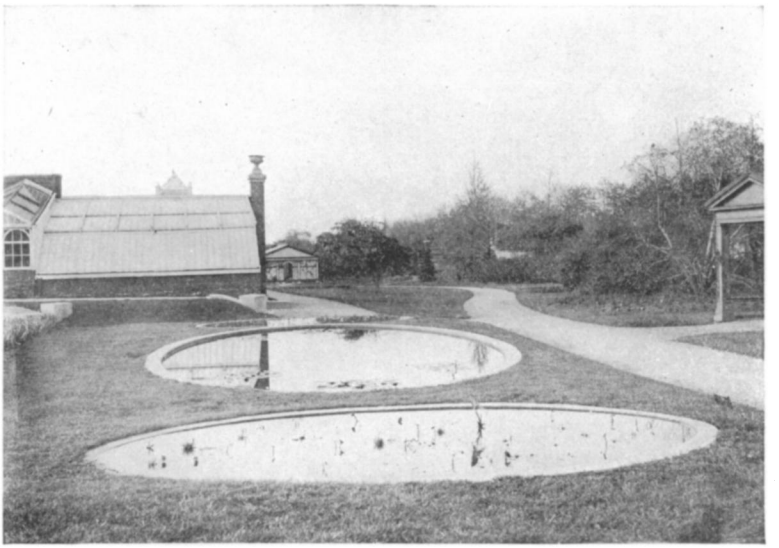


ARBORETUM POND—NORTHWEST SIDE.

ALGAL HABITATS.



CRESCENT POOL.



NYMPHAEA AND NELUMBIUM POOLS.